The effect of season on performance and blood metabolites of Holstein steers fed low or high grain diets in semi-arid climate

M. Danesh Mesgaran, A.R. Vakili and A. Heravi Moussavi
Department of Animal Science (Excellence Centre for Animal Science), Faculty of Agriculture, Ferdowsi University of Mashhad, Iran, P.O. Box: 91775-1163.
Corresponding author: Danesh@um.ac.ir

Introduction

Extreme or rapid changes in environmental conditions can often be detrimental to cattle performance and well-being (Webster, 1973; Hahn, 1995). However, if climatic changes are not too abrupt, cattle can buffer effects of, and adapt to, changing environmental conditions through physiological and metabolic processes. Kamal and Ibrahim (1969) reported that thyroid gland activity in summer was 16% less than in winter allowing for a decrease in metabolic rate and muscle activity to occur and overall heat production to be reduced. In addition, when cattle were exposed to heat stress, blood urea nitrogen levels were found to decrease by 16% in lactating cows and by 28 to 30% in calves (Habeeb *et al*., 1992). The depression in blood urea nitrogen appears to be a result of re-absorption from the blood to the rumen to compensate for the decrease in ruminal ammonia-N due to reduced feed intake (Habeeb *et al*., 1992). When cattle are exposed to cold stress, gastrointestinal tract motility increases due to an elevated metabolic rate, resulting from an increase in thyroid hormone activity (Westra and Christopherson, 1976; Kennedy *et al*., 1977). Thus, feed intake is often enhanced in cattle exposed to cold environments (NRC, 1996). There is evidence that when fed oestrogenic anabolic agents, IGF-I concentrations are increased (Breier *et al*., 1988; Johnson *et al*., 1998). Change in body temperature, particularly when cattle are under environmental stress, is another physiological characteristic that could be influenced by anabolic agents. However, no data are available regarding effects of anabolic agents on body temperature.

The aim of the present experiment was to determine the effect of season on feed intake, blood metabolites and body daily weight gain of Holstein steers fed diets providing different concentrate:lucerne hay ratios (C_{60}: L_{40}, C_{80}: L_{20}) in a semi-arid climate.

Materials and methods

The experiment was conducted in the east of Iran, during spring and summer, 2006; where average rainfall is 250 mm per year. Climatic conditions during the 2 seasons (spring and summer) were reported by weathercast centre of Iran. For the spring and summer periods, the ambient temperature averaged 18 and 33 °C, respectively, and ranged from a daily average of 15.2 to 25 °C for spring and 26 to 38 °C for summer.

Holstein steers (initial body weight 261±15 kg, n=30) were adapted to experimental diets for one week. Then, for 120 d, steers were fed diets differing in concentrate (155 g CP kg^{-1} of DM; 30% maize, 34% barley, 8% soybean meal, 5% sugar beet pulp, 10% wheat bran, 12% cottonseed meal, 0.3% $CaCo_3$, 0.5% mineral and vitamin premix, 0.2% salt) to lucerne hay (155 g CP kg^{-1} of DM) ratios as 60:40 (C_{60}: L_{40}) and 80:20 (C_{80}: L_{20}) in a completely randomized design. Steers were housed in individual pens, and fed the experimental diets as total mixed ration twice daily at 0800 and 2000 h. Refusals were removed before the morning feeding. Animals had access to drinking water at the all time. Daily weight gain was recorded every 4 weeks.

For both seasons, at day 60 (spring) and 120 (summer) of the experiment, blood samples were taken from the jugular vein at 2 and 4 h after the morning feeding. Blood samples taken were extracted for plasma by centrifugation (3000 rpm) for 20 min at 4 °C, and were stored at -20 °C until further analysis. Plasma samples were measured for glucose and urea N by Spectrophotometer (CE 1021, 1000 series, Cecil instruments Cambridge England). Duplicate analyses were performed on each sample for glucose and plasma urea nitrogen (PUN).

For Jugular blood pH, samples were collected using heparinized syringes approximately 4 h after the a.m. feeding. The syringes were chilled in an ice bath immediately and transported to the laboratory within 1 h. Blood pH was measured by Automatic blood gas system (AVL 995, Switzerland) adjusted for hematocrit and body temperature.

Data from sampling days were analyzed as repeat measures using the PROMIX of SAS (y= Mean + Treatment + Animal (Treatment) + Time + Treatment*Time + Residual) and the means compared by the Duncan test (P< 0.05).

Results

Feed intake and body weight gain are shown in Table 1. Jugular blood pH, and glucose and plasma urea nitrogen concentrations are shown in Table 2.

Table1 Feed intake and body weight gain of Holstein steers fed diets differing in concentrate:lucerne hay ratios during spring and summer in semi-arid climate.

Item	Concentrate: Lucerne hay ratio[1, 2]				Treatment effect		Season effect	
	C_{60}: L_{40}		C_{80}: L_{20}		SEM[3]	*P*	SEM	*P*
	spring	summer	spring	summer				
Feed intake (kg/d)	10	9.8	9.8	9.65	0.10	0.55	0.11	0.8
Weight gain (kg/d)	1.50	0.99	1.49	0.89	0.11	0.60	0.03	0.01

[1]When the difference between means in each row is greater than two times the SEM, it is considered as significant (P<0.05).
[2]Values were reported as the mean of 15 steers in each treatment.
[3]SEM= Standard Error of Mean

Table 2 Jugular blood pH, and glucose and plasma urea nitrogen concentrations of Holstein steers fed diets differing in concentrate: lucerne hay ratios during spring and summer in semi-arid climate.

Item	Time (h)	Concentrate: Lucerne hay ratio[1, 2]				Treatment effect		Season effect	
		C_{60}: L_{40}		C_{80}: L_{20}		SEM[3]	*P*	SEM	*P*
		60 d	120 d	60 d	120 d				
Blood pH	4	7.33	7.38	7.35	7.36	0.01	0.97	0.01	0.05
Glucose (mg/dl)	2	94.21	79.01	95.73	88.22	3.00	0.04	0.78	0.01
	4	98.78	88.93	103.83	88.93				
Plasma urea nitrogen	2	13.85	13.21	12.70	12.57	0.52	0.60	0.28	0.9
(mg/dl)	4	12.86	12.46	14.22	13.21				

[1]When the difference between means in each row is greater than two times the SEM, it is considered as significant (P<0.05).
[2]Values were reported as the mean of 15 steers in each treatment.
[3]SEM= Standard Error of Mean

Dry matter intake was not significantly affected by the season. However, the amount of DMI was numerically lower in summer.

Weight gain values were not affected by the treatments. However, it was influenced by the season (P< 0.05) The results of this study showed that the weight gain values were lower in summer than spring (0.94 vs. 1.495 kg/day/steer).

The results of the present study demonstrated that the increasing of concentrate in diets did not significantly affected blood pH. However, blood pH was affected by the season and was ranged from 7.33 (spring) to 7.38 (summer).

Plasma urea N values were similar among diets, but blood glucose values were affected significantly by the treatments and season (P< 0.05). Overall, seasonal effects were not found for PUN concentrations. In addition, the results of this study indicated that the plasma urea N values were not significantly influenced by the concentrate to lucerne hay ratios.

Conclusions

In a semi-arid climate lower weight gain in summer than spring might be associated with body physiological changes. Kamal and Ibrahim (1969) reported that thyroid gland activity in summer was 16% less than in winter allowing for a decrease in metabolic rate and muscle activity to occur, and overall heat production to be reduced. Thyroid activity influences digesta passage rate and digestibility in ruminants (Christopherson, 1985). Thyroid gland responses are also influenced by level of feed intake (Yousef and Johnson, 1985). Positive relationships have been found between thyroid hormone concentrations and energy balance (Murphy and Loerch, 1994; Hersom *et al*., 2004). Based on seasonal differences in body weight gain in the current study, it has been proposed to evaluate the thyroid activity in the next works.

In a semi-arid climate when steers were fed a high grain diet, the increase in the glucose concentration after realimentation was probably the result of a higher ruminal production of its precursor, propionic acid (Journet *et al*., 1995).

In the current study, Peak PUN concentrations were found on day 60 (in the spring). In the spring, during the period when ambient temperatures were lower, feed intake was stimulated and was associated with greater PUN levels than were found on summer. In the summer, ambient temperature would be peaking around day 120, thus suppressing feed intake and contributing to a lower PUN. Similarly, a 16% decline in PUN in the summer compared with winter-fed ruminants was reported previously (Habeeb *et al*., 1992). Habeeb *et al*. (1992) stated that this decline in summer PUN levels could be due to the decrease in DMI, thereby lowering ruminal nitrogen recycling, and causing reabsorption of nitrogen into the rumen from the blood. Kreikemeier and Mader (2004) reported the greatest and lowest DMI during d

36 to 69 in the winter and summer studies, respectively. Furthermore, Changes in PUN concentrations could be attributed to increases in protein synthesis, decreased protein degradation, or a combination of both.

Implications

This study examines the effect of season on feed intake, body weight gain and some blood metabolites of Holstein steers fed low or high grain diets during spring and summer in a semi-arid climate. An unfavourable effect of season on body weight gain and blood glucose concentration suggested that animals fed either diets had poor performance in summer compared with spring in the semi-arid climate.

Acknowledgements

The authors would like to acknowledge the Excellence Centre for Animal Science for financial support of this project.

References

Breier, B. H., P. D. Gluckman, and J. J. Bass. 1988. Influence of nutritional status and oestradiol-17β on plasma growth hormone, insulin-like growth factors-I and II and the response to exogenous growth hormone in young steers. Journal of Endocrinology. 118:243–250.

Christopherson, R. J. 1985. Endocrine systems and thermal environment. Pages 163–180 in Stress Physiology in Livestock: Basic Principles. CRC Press Inc., Boca Raton, FL.

Habeeb, A. A. M., I. P. M. Marai, and T. H. Kamal. 1992. Heat stress. Pages 27–47 in Farm Animals and the Environment. C. Phillips and D. Piggins, ed. CABI Publishing, Wallingford, UK.

Hahn, G. L. 1995. Environmental influences on feed intake and performance of feedlot cattle Pages 207–227 in Proc. Symp.: Intake by Feedlot Cattle. Oklahoma State Univ., Publ. no. P-942. F. N. Owens, ed. Oklahoma State University., Stillwater.

Hersom, M. J., R. P. Wettemann, C. R. Krehbiel, G. W. Horn, and D. H. Keisler. 2004. Effect of live weight gain of steers during winter grazing: III. Blood metabolites and hormones during feedlot finishing. Journal of Animal Science. 82:2059–2068.

Johnson, B. J., M. E. White, M. R. Hathway, C. J. Christians, and W. R. Dayton. 1998. Effect of combined trenbolone acetate and estradiol implant on steady-state IGF-I mRNA concentrations in the liver of wethers and the longissimus muscle of steers. Journal of Animal Science 76:491–497.

Journet, M., G. Huntington, and J. L. Peyraud. 1995. Le bilan des produits terminaux de la digestion. In: R. Jarrige, Y. Ruckebusch, C. Demarquilly, M. H. Farce, and M. Journet (Ed.) Nutrition des Ruminants Domestiques. Ingestion et Digestion. pp 671-720. INRA, Paris.

Kamal, T. H., and I. I. Ibrahim. 1969. The effect of the natural climate of the Sahara and controlled climate on thyroid gland activity in Friesian cattle and water buffaloes. Int. Journal of Biometeorology. 13:275–285.

Kennedy, P. M., B. A. Young, and R. J. Christopherson. 1977. Studies on the relationship between thyroid function, cold acclimation and retention time of digesta in sheep. Journal of Animal Science 45:1084– 1090.

Kreikemeier, W. M., and T. L. Mader. 2004. Effects of growth-promoting agents and season on yearling feedlot heifer performance. Journal of Animal Science. 82:2481–2488.

Mader, T. L. and W. M. Kreikemeier. 2006. Effects of growth-promoting agents and season on blood metabolites and body temperature in heifers. Journal of Animal Science. 84:1030-1037.

Murphy, T. A., and S. C. Loerch. 1994. Effects of restricted feeding of growing steers on performance, carcass characteristics, and composition. Journal of Animal Science. 72:2497–2507.

NRC. 1996. Nutrient Requirements of Beef Cattle. 7th ed. Natl. Acad. Press, Washington, DC.

Webster, A. J. 1973. Heat loss from cattle with particular emphasis on the effects of cold. Pages 205–231 in Heat Loss from Animals and Man: Assessment and Control. J. L. Monteith and L. B. Mount, ed. Butterworths, London, UK.

Westra, R., and R. J. Christopherson. 1976. Effects of cold on digestibility, retention time of digesta, reticulum motility and thyroid hormones in sheep. Canadian Journal of Animal Science 56:699–708.

Yousef, M. K., and H. D. Johnson. 1985. Endocrine systems and thermal environment. Pages 133–141 in Stress Physiology in Livestock: Basic Principles. CRC Press Inc., Boca Raton, FL.